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Progress Report Outlining Work

ON

Contract Nonr-248(37), NR 083-038/7-28-52

for

Period Ending 31 January 1953

Contractor: The Institute for Cooperative
Research
of
The Johns Hopkins University
Baltimore, Maryland

Prepared By: G. Frank Miller

ESTUARINE CURRENT METER CONTRACT

Purpose:

The purpose of this program is to develop a suitable instrument for measuring accurately and recording continuously the velocity of the water at a fixed point in an estuary. The instrument is to be left in position for a seven-day period, during which it will record the magnitude and direction of the current vector. The instrument is to have a range extending from a minimum of 0.05 knot (approximately 0.085 feet per second) to a maximum of 3 knots (approximately 5.1 feet per second). At a meeting held in the office of Mr. B. K. Couper of the Bureau of Ships on October 1, 1952, it was agreed that if possible the accuracy at the low velocity end should be ± 0.01 foot per second, and ± 0.05 foot per second at the high velocity end of the range. Modification of these accuracy figures, as dictated by necessity, were to be cleared with Dr. Pritchard of the Chesapeake Bay Institute — this was the suggestion of Mr. Couper at the October meeting. On December 18th the Homewood group met with Dr. Pritchard for a discussion of the progress of the work. After a lengthy discussion of some of the problems arising from the wide range of velocities to be handled, Dr. Pritchard suggested that some relief be given on the accuracy of the low velocity end by making it ± 0.05 foot per second over the entire range of the instrument. This newer figure is being used in all present calculations.

In addition to the above specifications, it was agreed that the

instrument should have no external moving parts of the type requiring rotating or sliding bearings; and must be small in size and light in weight to facilitate handling.

The maximum depth of operation for the sensing element was set at 200 feet at the October 1st meeting.

Outline of Progress:

A review of the literature has been made, and the problem has been discussed with individuals interested in the application of such instruments. Of the many ideas suggested and investigated, two methods of measuring the velocity seem most promising: (1) a system for measuring the force exerted on a solid body submerged in the flow, and (2) a system for measuring the difference in time taken by a sound wave to traverse a fixed distance in the direction of and against the current.

Dr. Li is investigating the method (1), employing the drag on a submerged solid body, and has decided that a circular disc about 6 inches in diameter so oriented that its circular faces are normal to the current should be suitable. With this disc, the drag coefficient is constant throughout the range of velocities to be measured. He has estimated that when the normal to one of the disc faces is inclined at an angle of 10 degrees from the direction of flow, the drag will differ by only one per cent from its value when the normal to the disc is parallel to the direction of the flow. The disc is to be attached to one end of a slender rod

which acts as a cantilever beam (Figure 1). The drag on the disc is indicated by the difference in inclination of the two ends of the rod. The use of two Y-type Position Convectorons (manufactured by the Eclipse-Pioneer Division of the Bendix Aviation Corporation) has been suggested as a possible means of measuring this difference. One convectoron will be housed within the drag disc, and the other in the body of the instrument where the "fixed" end of the cantilever is embedded. A spring whose response is proportional to the one-third power of the applied force will bring the range of inclinations within the range of the convectoron. Preliminary investigations show that the required accuracy can be obtained with this arrangement.

Mr. Middleton is working on the design of the elements of the ultrasonic system. In this system it is presently planned to use two crystal transducers separated by a path length of approximately 26 inches, which will alternately transmit and receive a one-megacycle signal. The velocity of the medium will be obtained from a comparison of phase between the two signals for travel with and against the current. The transducers will occupy a volume of approximately one cubic inch, and will be suspended approximately 4 inches below a beam which determines their separation. A tentative arrangement of electrical and electronic components has been made, and it is believed that the error can be held within ± 0.05 foot per second over the range of the instrument.

In view of the high accuracy demanded and the low velocities to be encountered, it is considered necessary that the instrument be anchored

to the bottom of the estuary. Any other arrangement, such as suspending the instrument from a float or boat, will subject the instrument to induced velocities many times the low velocities to be measured. It is contemplated that the overall specific gravity will be less than unity. The instrument will be attached to an anchor on the bottom of the estuary by a suitable cable system.

In both the methods mentioned above, it is necessary that the instrument should be able to orient itself automatically to the direction of the current. In addition, the instrument should maintain a fixed position relative to the vertical. In the first system, the cantilever should maintain a vertical position, while in the second case the ultrasonic path should remain horizontal. To accomplish this, Dr. Li has proposed the arrangement shown in Figure 1 -- essentially an "airfoil" with two end-fins. The fins help to orient the instrument to the direction of the current, while the airfoil stabilizes the instrument with respect to the vertical. The latter aim is accomplished because of the fact that the hydrodynamic forces acting on the instrument are proportional to the square of the velocity of flow, and the ratio of the drag to the lift is independent of the speed of the current. Thus, except for the gravitational force which can be reduced to a minimum by making the overall specific gravity very close to and slightly less than unity, the ratio of the horizontal force to the vertical force acting on the instrument is constant. The position of the cable and the instrument relative to the vertical is

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therefore practically independent of the magnitude of the velocity.

The investigation has reached the stage where preliminary model work has been started on both systems.

The convectrons mentioned above have been received, and their static and dynamic performance characteristics are presently being determined.

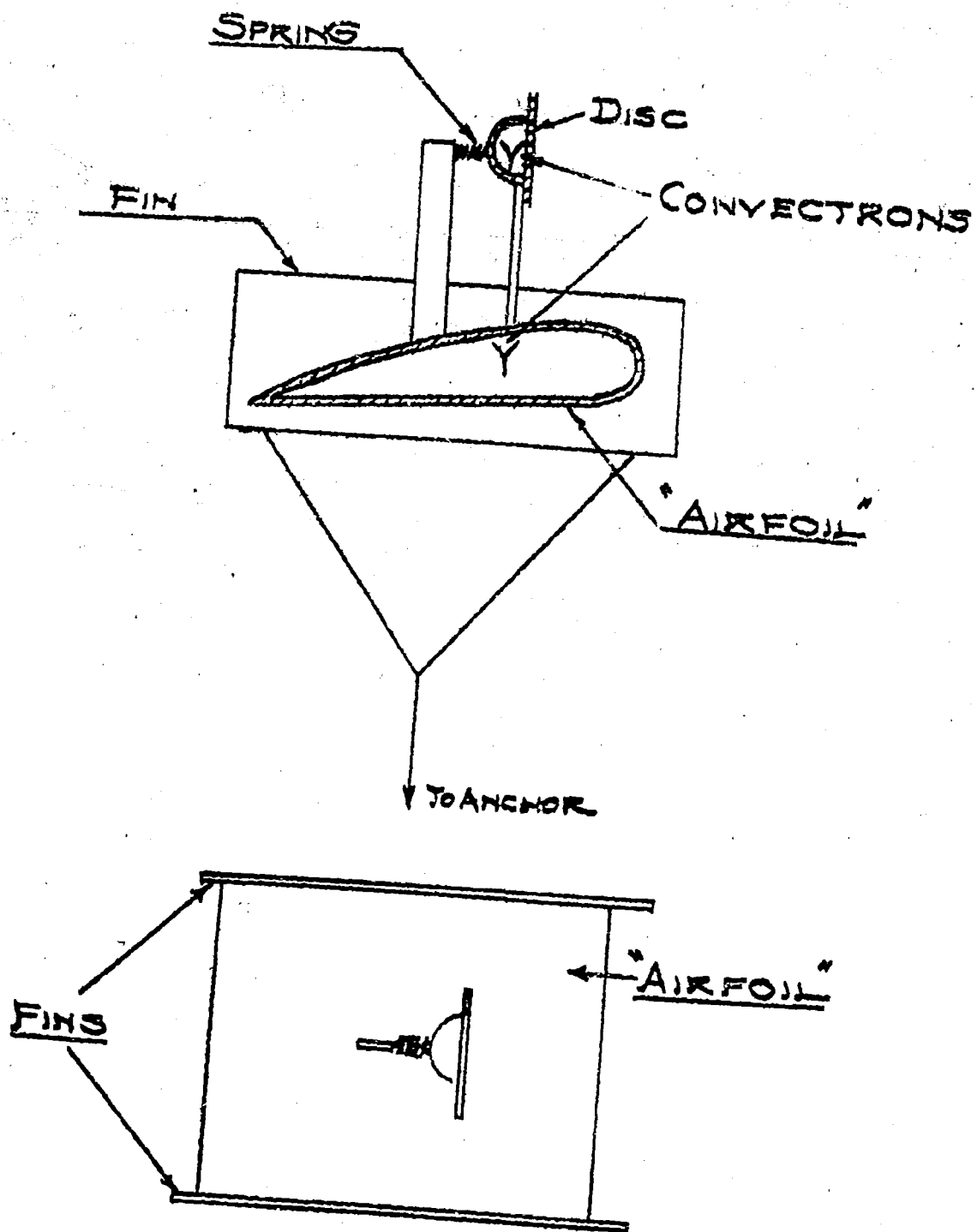


FIG. 1

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